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Micronutrient Assessment of Cocoa, Kola, Cashew and Coffee Plantations for Sustainable Production at Uhonmora, Edo State, Nigeria

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ABSTRACT

The micronutrient status of the soils and leaf of cocoa, kola, cashew and coffee plantations to study the soil-plant micronutrient content relationship in the plantation soils for proper management towards optimum production of the crops was investigated at Uhonmora, Edo State, Nigeria. Soil and leaf samples were collected from these plantations and analyzed according to standard laboratory procedures. The soil samples were analyzed for the micronutrients (Cu, Mn, Zn and Fe) and in addition pH, organic carbon, sand, silt and clay contents, while the leaves were analyzed for only the micronutrient contents. Results indicated that the soils were sandy loam, acidic, low in organic carbon, deficient in Cu and Mn but very high in Fe and Zn contents. This probably resulted in nutrient imbalance in the soils and the deficiency of the nutrients in the crops. The plantations therefore require application of organic manures and micronutrient fertilizers to rectify the inadequate soil organic matter and to supply sufficient amount of Cu and Mn in the soils, to obtain quality fruit yield at optimum level from the plantations.

Keywords: Cashew, cocoa, coffee, kola, micronutrients, sustainable production

INTRODUCTION

Micronutrients are essential chemical elements needed in small quantity for normal growth and development of crops (McKenzie 2001). When tree crops cannot get the micronutrients (Zn, Cu, Mn, B, Fe and Cl) in the required amount or when their supply is not proportionally balanced, they do not grow or develop properly, and may slowly die. Cocoa (*Thoebroma cacao*), kola (*Kola nitida*), cashew (*Anacadium occidentale*) and coffee (*Coffee arabica*) are tree crops which are very sensitive to the quantity and proportion of supplied nutrients for growth and development. Nigerian farmers rarely apply fertilizers on their farms hence; crops depend on natural supply of nutrients and more importantly, micronutrients, which are supplied from the soil with no effort through fertilizer application (Iremiren and Ekhomun 2005).

Studies on cocoa, kola, cashew and coffee production and fertilizer usage over the years have been mainly on macronutrients with less emphasis on micronutrient needs of the crops (Omotosho 1974; Falade 1978; Ojeniyi 1980; Chude and Obigbesan 1983; Afolabi and Egbe 1984). Hence, information dissemination to farmers on fertilizer usage for plantation crops has been majorly on macronutrient elements with no micronutrient recommendation; while most of the farmers do not even apply the recommended fertilizers due to their scarcity and lack of purchasing power as a result of low income.

The contribution of cocoa, kola, cashew and coffee to Nigeria economy showed that cocoa production is presently 240,000 metric t yr^{-1} from 307,000 metric t yr^{-1} (CBN 2010). Nigeria produces about 85,000 metric t yr^{-1} of kola nuts compared to the previous figure of 127,000 metric t yr^{-1} (Adebiyi *et al*. 2011). Coffee production has declined to about 186,000 metric t yr^{-1} as against 270,000–350,000 metric t yr^{-1} previously produced (Ibiremo and Fagbola 2008). Nigeria is the third largest producer of cashew nut in the world with a capacity of 850,000 metric t yr^{-1} in 2000–2005 but the present production capacity of 660,000 metric t yr^{-1} is reported by FAO (2010). This, however, indicates that production level is consistently on the decline.

Most of the plantations are over 50 years old and have become wasteful assets owing to old age, poor maintenance and lack of fertilizer application, severe pests and diseases attack as well as a combination of these factors (Ipinmoroti *et al.* 2009). Attempt to replant the plantations with improved seedlings have not been successful due to high soil Cu residue on cocoa plantations (Ayanlaja 1983), deficient and imbalanced soil nutrients (Ipinmoroti *et al.* 2011). It therefore shows that decline in soil fertility, imbalance use of fertilizer nutrients are subjects of concern towards solving low yield of the crops in most of the plantations in Nigeria. Nigerian soils lack of adequate plant nutrients and organic matter (Ogunwale *et al*. 2002). Hence, most of the tree crop plantations in Nigeria are established on medium to low fertility status soils (Egbe *et al*. 1989) with resultant low yield by farmers.

Improper fertilizer recommendation because of lack of adequate soil testing (Ogunlade *et al*. 2011) has resulted to imbalance supply of nutrients to crops. This study was therefore carried out to assess the micronutrient status of some old cocoa, coffee, cashew and kola plantations in Uhonmora area of Edo State, Nigeria for possibility of remedying deficiency and imbalance for optimal performance of the plantations.

MATERIALS AND METHODS

Soil Preparation

Ten soil samples from 2 ha area each from the cocoa, kola, cashew and coffee plantations were collected at 0-30 cm soil depth. These soil samples from each plantation were processed and uniformly mixed to form a composite sample per plantation. Indicator leaf samples, fourth matured leaf from the tip of the plant branches, were collected from four cocoa, kola, cashew and coffee trees which were very close to the point of soil sample collections. Leaf samples were oven-dried to constant weight at 70 ^oC and milled using Hammar mill (ML 100).

Soil Analysis

The soil pH was determined in soil-water (1 : 2.5) suspension using the digital electronic pH meter, soil organic carbon was determined by the procedure of Walkley and Black by wet oxidation using chromic acid digestion (Nelson and Sommers 1982). The soil micronutients – Cu, Zn, Mn and Fe were determined after extraction of the soils with 0.1*N* HCl and the filtrate was read by use of Perkin-Elmer Atomic Absorption Spectrophotometer (AOAC 1990). The plant samples were ashed with Murphy furnace at 500 ^oC for 5 hours, cooled, dissolved with 5-mL of 0.4 *N* HCl and leached to 100-mL with distilled water. The filtrates were determined for the Cu, Zn, Mn and Fe contents by use of Perkin-Elmer Atomic Absorption Spectrophotometer. Micronutrient need was calculated based on individual element critical level and crop requirements, while the organic carbon needs were by direct calculation according to each plantation soil level.

RESULTS AND DISCUSSION

The particle size, organic carbon content and pH of the plantation soils are presented in Table 1. The plantation soils were generally sandy loam in texture. The sand fraction ranged from 754–818 g kg^{-1}, the silt fraction from 9.6–13.1 g kg^{-1} and the clay fraction from 6.5–13.7 g kg^{-1}. The organic carbon content ranged from 4.7–23.5 g kg^{-1}. These were generally lower than 30 g kg^{-1} considered optimum for tree crop plantation (Egbe *et al*. 1989). The sandy nature of the soil and the very low level of organic carbon indicate that micronutrient supply, availability and uptake by crops will be difficult. This is because soils low in organic carbon (less than 20 g kg^{-1}) are prone to have lower micronutrient availability, while soils that are coarse textured (sandy soils) are more likely to be low in micronutrients (McKenzie 2001). The range of the soil pH was from 4.9–5.7 which indicated that they were acidic. This however, falls below 6.0–6.5 reported to be normal for tree cops like cocoa, coffee, cashew and kola (Opeke 1987). The soil pH will need to be corrected with the use of organic materials or liming materials or manures for optimal microbial activities in the soils and ease of

Table 1. Particle size of soil, textural class, organic carbon content and pH of the plantation soils.

Crop plantation	Sand	Silt	Clay	Texture class	Organic carbon	pH
	.... g kg^{-1}				(g kg^{-1})	
Cocoa	810	125	65	Sandy loam	5.3	5.7
Cashew	754	112	134	Sandy loam	9.3	5.7
Kola	762	131	107	Sandy loam	4.7	4.9
Coffee	818	96	86	Sandy loam	23.5	5.1

macronutrient release for crop usage. This will also help to make sure that micronutrients are not released in a rate too much for normal crop growth and production performance.

The soil micronutrient content presented in Table 2 showed that the soils vary in the amount of Zn, Cu, Fe and Mn values in all the plantations. The Cu contents ranged from 0.39–2.57 mg kg^{-1} soil, with lower values in the kola and cocoa plantations compared to those of cashew and coffee plantation soils. The soil Cu level was only adequate for the coffee plantation, while it was below the soil critical level of 2.5 mg kg^{-1} (McKenzie 2001) for the cocoa, kola and cashew plantation soils. The Mn content in the cocoa plantation soil was 2.94 mg kg^{-1}. This was higher than that of kola, coffee and cashew plantations whose Mn content values ranged from 0.03 – 0.94 mg kg^{-1}. When compared with soil critical level of 1.0 mg kg^{-1} (McKenzie 2001) the soil Mn content was adequate in the cocoa plantation, while it was generally deficient in the soils of the cashew, coffee and kola plantations.

The soil Zn content ranged from 30.1–54.2 mg kg^{-1} as shown in Table 2. The values were generally higher than the soil critical value of >1.0 mg kg^{-1} (McKenzie 2001).This indicates that the soil Zn content was adequate and would not be a source of nutritional problem in the plantations. The Zn level in the soil was similar for both coffee and cashew plots, which were significantly higher than values obtained from the cocoa and kola The plantations. The soil Fe content ranged from 124– 32 mg kg^{-1}, with cashew plot having the highest value of 232 mg kg^{-1} while the least was recorded for the cocoa plot. However, the soil Fe contents were far above the critical value of >4.5 mg kg^{-1} (McKenzie 2001) considered adequate for tree crops. Hence, the values were considered adequate and sufficient to meet the requirements for the plantation crops.

Table 2. Some micronutrient contents of the plantation soils.

Crop plantation	Cu	Mn	Zn	Fe
	.... mg kg^{-1} soil			
Cocoa	1.38	2.94	32.4	124
Cashew	1.94	0.94	53.6	232
Kola	0.39	0.03	30.1	198
Coffee	2.57	0.06	54.2	208

Table 3. Leaf micronutrient contents for each crop.

Crop plantation	Cu	Mn	Zn	Fe
	.... mg kg^{-1}			
Cocoa	1.22	0.29	47.07	32.89
Cashew	2.08	0.58	8.89	23.33
Kola	2.11	0.15	20.92	27.85
Coffee	3.17	1.16	36.61	31.27

The leaf micronutrient contents are presented in Table 3. The crop leaf Cu content ranged from 1.22 – 3.17 mg kg^{-1} dry matter weight. The values were far below the critical level of 8.0 mg kg^{-1} dry weight (McKenzie 2001) considered sufficient for the tree crops. Similarly, the leaf Mn content were grossly found to be too low with a range from 0.29–1.16 mg kg^{-1} dry weight, when compared with the values of 25.0 mg kg^{-1} dry weight (McKenzie 2001) calculated to be sufficient for tree crops. .The plant leaf contents of Zn in all the plantations ranged from 8.89–47.07 mg kg^{-1} dry weight. The value for the cashew plant was too low in the crop when compared to established critical level of 20 mg kg^{-1} dry weight (McKenzie 2001). It was marginal for kola, while it was considered to be sufficient for both the cocoa and coffee plants.

The plantation soils were coarse textured and very low in their organic carbon contents, which are common factors that make micronutrients not to be available for plant uptake in the soil (McKenzie 2001). The general trend of the soil micronutrient contents showed that the plantations soils were very low to marginal in their Cu and Mn levels. The soils could therefore not meet the required supply of the plantation crops for these nutrients. This is a clear indication that the crops would find it highly impossible to bear quality fruits at optimum levels. On the other hand, Zn and Fe which were found to be adequate in the plantation soils but not sufficiently supplied to the crops was an indication of nutrient imbalance in the soils. This indicates the situation of antagonistic reactions between the micronutrients in the soils. Hence, the micronutrients found to be adequate in the soil could not be sufficiently supplied to the crops. Therefore, production level from the plantation crops is expected to be low. Nutrient imbalance is a problem to crop development and productivity. It has been reported that high content of Cu, Fe and Mn in the surface soil and low organic carbon lead to imbalance that courses constraints in getting good cocoa seedling establishment (Ayanlaja 1983). The situation in the plantations portrays the state of organic matter and micronutrient deficiency and nutrient imbalance which must be corrected.

Table 4. Microutrient (kg ha^{-1}) and manure (t ha^{-1}) needs on the plantations.

Crop plantation	Zn	Cu	Mn	Fe	Manure
Cocoa	-	4.48	-	-	24.7
Coffee	-	2.24	0.24	-	20.7
Kola	-	8.44	3.88	-	25.3
Cashew	-	-	3.76	-	6.5

micronutrient needs of the plantation to avert deficiency and optimum crop production are presented in Table 4. Based on the individual plot deficiency levels for organic matter and the micronutrients, the micronutrient need was calculated based on individual element critical level. The plantations would therefore need the application of 6.5–25.3 t ha^{-1} of manure so as to meet the organic carbon needs of the plantations. This will help to buffer the soils against the soil pH from becoming too acidic or alkaline. It will also serve as a secondary source of micronutrients upon decomposition and mineralization. Adequate manure in the soils will help to increase the soil CEC levels which were naturally low due to inherent low clay and organic matter contents of the tropical soils (Ogunwale *et al*. 2002).

The plantation soils would need application of 2.24–8.44 kg ha^{-1} of Cu and 0.24–3.88 kg ha^{-1} of Mn, as copper sulphate and manganese sulphate respectively, in order to meet the deficient level of Cu and Mn of the plantations as shown in Table 4. The kola plantation had the highest amount of Cu and Mn requirement due to the very low level of the nutrients in the plantation soil. This might be due to excessive removal of the nutrients from the soil over the years through pod harvest which were not returned into the soils. The sufficiency of the plantation soils in Zn and Fe showed that the nutrients were not need to be applied to the plantations, while Cu and Mn fertilizers would not be needed in the coffee and cocoa plots respectively.

CONCLUSIONS

This investigation has been able to reveal the importance of micronutrient in the nutrition of these plantation crops. It was recorded that the plantation soils are very low in organic carbon, Cu and Mn contents but high in Zn and Fe contents, which must have lead to nutrient imbalance and deficient supply of the nutrients to the plantation crops. To correct the micronutrient imbalance on the plantations, suggestion therefore is that adequate auditing of the soil nutrients are needed to be carried out periodically. This can be at the end of every cropping season main harvest, in order to know the soil nutrient balance. Wherever insufficiency of any of these nutrients are observed and corrections are made appropriately in the next growing season to guide against low crop yield and poor quality harvest.

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